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[c1] **What is claimed is:**

An emission electron source comprising:

a first cathode electrode disposed on a substrate, the cathode electrode for providing a source of electrons;

an emitter layer being disposed over the said cathode electrode and formed from a composition of an embedding material and one or a plurality of vertically oriented and mono-dispersed nano-structures embedded therein, the emitter layer having a surface, parallel to which the nano-structures are truncated to substantially the same length and above the surface the nano-structures protrude for emitting electrons;

an insulator disposed over the emitter layer, the insulator having one or a plurality of apertures, each is aligned with and exposes one nano-structure in the emitter layer;

a second gate electrode disposed over the insulator and having one or plurality of apertures aligned with the apertures in the insulator, the gate electrode for controlling the emission of electrons through the apertures from the exposed nano-structures.

- [c2] An electron source as recited in claim 1, wherein the gate aperture has a size substantially less than one micrometer.
- [c3] An electron source as recited in claim 1, wherein the nano-structures have a surface density substantially higher than $10^6/\text{cm}^2$.
- [c4] An electron source as recited in claim 3, wherein the nano-structures are grown from a plurality of catalyst dots patterned by depositing the said catalyst through a mask.
- [c5] An electron source as recited in claim 4, wherein the mask includes membranes formed from ion-track etching and membranes formed from etching using an ion-track-etched membrane as a mask.
- [c6] An electron source as recited in claim 1, wherein the nano-structures include nano-tubes, nano-wires, nano-fibers, and nano-cones.

- [c7] An electron source as recited in claim 1, wherein the nano-structures are pre-fabricated and placed onto the cathode electrode by a self-assembly process.
- [c8] An electron source as recited in claim 1, wherein the nano-structures are conductive and the embedding ma-

terial is nonconductive.

- [c9] An electron source as recited in claim 8, wherein the conductive nano-structures are selected from a group of materials consisting of carbon, refractory metals and alloys, conductive ceramics, conductive ceramic composites, and doped semiconductors.
- [c10] An electron source as recited in claim 9, wherein the carbon include carbon nano-tube, carbon nano-fiber, and carbon nano-cone.
- [c11] An electron source as recited in claim 8, wherein the conductive nano-structures have a thin coating for enhanced field emission performance.
- [c12] An electron source as recited in claim 8, wherein the conductive nano-structures comprise of a nonconductive core and a conductive shell.
- [c13] An electron source as recited in claim 12, Wherein the nonconductive core is made from one of wide band gap semiconductors, including diamond, BN, AlN, AlGaN, GaN, GaAs, SiC, ZnO.

- [c14] An electron source as recited in claim 1,
wherein the nano-structures are non-conductive; and
wherein the embedding material is conductive, the con-
ductive material for providing a means for electron
transfer from the first electrode to the nano-structure
for electron emission.
- [c15] An electron source as recited in claim 14, wherein the
non-conductive nano-structures are made from one of
the wide band gap semiconductors, including diamond,
BN, AlN, AlGaN, GaN, GaAs, SiC, ZnO.
- [c16] An electron source as recited in claim 1, wherein the
nano-structures are truncated by chemical mechanical
planarization.
- [c17] An electron source as recited in claim 1, wherein the in-
sulator and the embedding material is the same dielec-
tric material.
- [c18] An electron source as recited in claim 1,
wherein the nano-structures are grown using a template
and the said template is the embedding material.

[c19]

An electron source as recited in claim 1,

wherein the first cathode electrode is configured as a plurality of electrically isolated cathode electrodes, each for supplying an independent source of electrons;

wherein the second gate electrode is configured as a plurality of electrically isolated electrodes, each intersecting with the said plurality of cathode electrodes and having one or a plurality of apertures aligned with the apertures in the said insulator at the intersections, each gate electrode for controlling the emission of electrons through the apertures along the gate electrode;

activation of a selected cathode and a selected gate electrode determines an intersection where the nano-structures emit electrons.

[c20] A display comprising:

an electron source including: a first cathode electrode disposed over a substrate; an emitter layer being disposed over the said first electrode and formed from a composition of an embedding material and one or a plurality of vertically oriented and mono-dispersed nano-structures embedded therein, the emitter layer having a surface, parallel to which the nano-structures are truncated to substantially the same length and above the surface the nano-structures protrude for emitting electrons; an insulator disposed over the emitter layer and having one or a plurality of apertures, each is aligned with and exposes one nano-structure in the emitter layer; a second gate electrode disposed over the insulator and having one or plurality of apertures that are aligned with the apertures in the insulator; and an anode plate including a transparent anode electrode

disposed over a glass substrate and a phosphor screen disposed over the anode electrode, and being positioned opposite to said electron source with a vacuum gap put therebetween; whereby electrons are emitted from said nano-structures by applying a voltage between said cathode and gate electrodes, and are made incident on said phosphor screen to make luminous said phosphor screen.

- [c21] A display as recited in claim 20, wherein the gate aperture has a size substantially less than one micrometer.
- [c22] A display as recited in claim 20, wherein the nano-structures have a surface density substantially higher than $10^6/\text{cm}^2$.

[c23]

A display as recited in claim 20,

wherein the first cathode electrode is configured as a plurality of strip-like cathode electrodes extending substantially in the same direction in such a manner as to be spaced from each other at intervals in the transverse direction, each cathode strip for providing an independent source of electrons;

wherein the second gate electrode is configured as a plurality of strip-like gate electrodes extending in such a manner as to intersect the said plurality of cathode electrodes and to be spaced from each other at intervals in the transverse direction, and having one or a plurality of apertures aligned with the apertures in said insulator at the intersections, each gate electrode for controlling the emission of electrons through the apertures along the gate electrode; and

wherein the anode electrode is configured as a plurality of strip-like anode electrodes each extending in such a manner as to be opposed to the corresponding one of the said second gate electrodes.

[c24] A method of fabricating an electron source, the method comprising:
providing a substrate;
depositing on the substrate a first conductive layer;
depositing one or a plurality of vertically oriented and mono-dispersed nano-structures over the first conductive layer;
comformally depositing a material to embed the nano-structures, forming an emitter layer with a surface above which ends of the nano-structures are to protrude;
truncating the nano-structures to substantially the same length by polishing the surface of the emitter layer;
etching back the embedding material from the polished

surface so that the ends of the nano-structures protrude above the surface for a small fraction of one micrometer; conformally depositing an insulator over the surface of the emitter layer for a thickness substantially less than one micrometer, forming a post from each nano-structure; depositing a second conductive layer over the insulator; removing the insulator and the second conductive layer from the nano-structures to form apertures in the second conductive layer and in the insulator, whereby nano-structures are exposed at the center of each of the aperture for electron emission and control.

- [c25] A method as recited in claim 24,
wherein nano-structures are deposited over the first
conductive layer by: depositing one or a plurality of
nano-sized catalyst dots on the first conductive layer;
and growing one nano-structure from each of the said
catalyst dot.
- [c26] A method as recited in claim 25, wherein nano-sized
catalyst dots are deposited over the said first conductive
layer through a mask.
- [c27] A method as recited in claim 26,
wherein the mask includes membranes formed from ion-
track etching and membranes formed from etching using

an ion-track-etched membrane as a mask.

- [c28] A method as recited in claim 24,
wherein the nano-structures are grown by using a tem-
plate; and
wherein the embedding material is the said template.
- [c29] A method as recited in claim 24,
wherein the nano-structures are deposited over the first
conductive layer using pre-fabricated nano-structures.
- [c30] A method as recited in claim 24,
Wherein the nano-structures are truncated by chemical
mechanical planarization.
- [c31] A method as recited in claim 24,
wherein the second conductive layer is thinner than the
insulator and deposited by a line-of-sight process such
that it is only deposited on top of the posts and on the
floor surface at the bottom of the posts; and
wherein the insulator and the second conductive layer
are removed from the nano-structures by etching the in-
sulator on the posts.

- [c32] A method as recited in claim 24,
wherein the insulator and the second conductive layer
are removed from the nano-structures by: removing the
posts using chemical mechanical planarization to form

apertures in the gate electrode; and etching back the in-
sulator using the gate electrode as a mask.
- [c33] A method as recited in claim 24,
wherein the removal of the insulator and the second
conductive layer from the nano-structures comprises of:
spin coating the surface with a positive photo resist after
the deposition of the second conductive layer; exposing
the photo resist with a UV illumination in such a manner
as to only the portions of the resist directly on top of the
post is removed after resist development; etching the
second conductive layer and the insulator through the
resist mask; and stripping the photo resist.

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[c35]

A method of growing one or a plurality of mono-dispersed nano-structures of predetermined
diameter and average spacing to be used as field emission emitters, the method comprising:

providing a proper substrate that is ready to accept growth of nano-structures;

laying down a mask over the said substrate, the mask consisting of a thin sheet of material punctuated with one or a plurality of fine pores of desired diameter and average spacing between pores;

depositing one or a plurality of catalyst dots on the substrate through the said mask;

removing the mask;

growing one nano-structure from each said catalyst dot.

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[c34]

A method as recited in claim 33,

wherein the mask includes ion-track etched membranes and membranes formed from etching using an ion-track-etched membrane as a mask.

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[c35]

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A method as recited in claim 34, wherein the ion-track etched membrane is pre-fabricated.

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[c36]

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A method as recited in claim 34,

wherein the ion-track etched membrane is fabricated on the substrate by: coating the substrate with a solid thin film, and subjecting the coated substrate to ion tracking and etching processes to form fine pores in the film.